The Effect of Injury Severity on the Incidence and Resource Utilization-Related Outcomes of Deep Vein Thrombosis Among Pediatric Trauma Admissions in the United States

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Background

Deep vein thrombosis (DVT) is a serious sequelae associated with traumatic injury. Previous studies have acknowledged that the number of DVT events among pediatric trauma patients is low and treatment guidelines are not well advanced.[1] Further, there is little information on the predictors of, and inpatient costs and other outcomes associated with, DVT among pediatric trauma patients.

Study Objective

The objective of this study was to generate national estimates of the effect of injury severity on the incidence and associated resource utilization-related outcomes of DVT among pediatric (≤ 20 years of age) traumatic injury-related inpatient stays in the United States.

Methods

Study Design

Retrospective database analysis

Data Source

Discharge data from the 2003 Healthcare Cost & Utilization Project (HCUP) Kids' Inpatient Database (KID)

- KID is the largest all-payer pediatric (≤ 20 years of age) inpatient care database in the United States
- KID is the only national pediatric hospital database with charge information on all patients, regardless of payer
- KID includes many clinical and non-clinical variables for each inpatient stay, including patient demographics, diagnosis codes, length of stay, total charges, admission and discharge status, payer, and hospital-specific characteristics
- Sampling weights allow for generating nationally representative estimates
- The 2003 dataset contains data for 2,984,129 (weighted N=7,409,162) million pediatric inpatient stays

Inclusion Criteria

- ≥1 ICD-9-CM diagnosis code consistent with traumatic injury, excluding injuries due to late effects of injury, blisters, abrasions, insect bites, and foreign bodies
  — ICD-9-CM codes 800.xx-959.xx, excluding 905.xx-924.xx and 930.xx-939.xx (inclusive of all 4th and 5th digit modifiers, where appropriate)

Key Analysis Variables

- DVT: ≥1 ICD-9-CM diagnosis code consistent with DVT
  — ICD-9-CM codes 452.0x, 453.0x, 453.2x, 453.3x, 453.4x, 453.8x, 453.9x, and 415.1x (inclusive of all 5th digit modifiers, where appropriate)
- Injury severity: ICDMAP-90 software[2] used to assign Injury Severity Score (ISS) categories[3]
  — 1-8: Minor — 9-15: Moderate — 16-24: Severe — 25+: Critical

Outcome Measures

- Probability of DVT
- Per-discharge total costs
  — KID's charge data converted to costs using facility-specific cost-to-charge ratios
  — Costs converted to 2007 US dollars
- Per-discharge length of stay (LOS)

Regression models

- $DVT_d = \beta_0 + \beta_1 ISSCAT_i + \beta_j X_j$, where DVT_d is a dichotomous DVT indicator (e.g., had DVT=1, no DVT=0), ISSCAT is a vector of dummy variables corresponding to injury severity (minor injury is the reference category), and X is a vector of explanatory variables including age, gender (female is the reference category), White race (non-White is the reference category), geographic region (Northeast is the reference category), facility teaching status (non-teaching is the reference category), urban facility (rural is the reference category), injuries (i.e., separate dichotomous measures for head injury, lower extremity fracture, pelvic fracture, spinal cord injury, and major vascular injury), and inpatient procedures (i.e., separate dichotomous measures for central venous line placement, craniotomy, spinal procedure, open reduction/fixation of lower extremity fracture, and laparotomy). Each β is the estimated effect of the parameter in question on the outcome of interest, and is subsequently converted to an odds ratio for ease of interpretation.

- $OUTCOME_c = \beta_0 + \beta_1 DVT + \beta_i ISSCAT_i + \beta_j ISSDVT_j + \beta_k X_k, + \varepsilon$, where $OUTCOME_c$ is a continuous outcome (e.g., total costs, LOS), DVT is a dichotomous DVT indicator, ISSCAT is a vector of dummy variables corresponding to injury severity (minor injury is the reference category), ISSDVT is a vector of interaction terms between ISS categories and DVT indicator, X is a vector of explanatory variables including age, gender (female is the reference category), White race (non-White is the reference category), and geographic region (Northeast is the reference category), and ε is the error terms. Each β is the estimated incremental effect of the parameter in question on the outcome of interest.

Other

All analyses were conducted using SUDAAN® software, version 9.0, to account for the KID's complex survey design

Descriptive Statistics

Table 1. Summary of Patient-Specific Characteristics, Overall and by DVT Status

	All Traumatic Injuries			With DVT			No DVT		
Parameter	Unweighted n	Weighted n	Weighted %	Unweighted n	Weighted n	Weighted %	Unweighted n	Weighted n	Weighted %
Female	46,060	76,013	31.62	113	179	27.57	45,947	75,835	31.63
White	59,408	99,159	41.25	188	303	46.79	59,220	98,856	41.23
Minor Injury	94,521	155,125	64.53	89	144	22.22	94,432	154,981	64.65
Moderate Injury	25,441	41,645	17.32	107	170	26.18	25,334	41,475	17.30
Severe Injury	14,871	24,485	10.19	83	134	20.66	14,788	24,351	10.16
Critical Injury	6,527	10,619	4.42	107	170	26.22	6,420	10,450	4.36
Indeterminate Injury Severity	5,152	8,514	3.54	19	31	4.72	5,133	8,483	3.54
Teaching Hospital	94,202	156,522	65.11	304	494	76.36	93,898	156,027	65.08
Urban Facility	131,463	212,726	88.49	384	613	94.60	131,079	212,113	88.48
Northeast	23,991	42,877	17.84	43	77	11.86	23,948	42,800	17.85
Midwest	36,009	54,381	22.62	131	194	29.96	35,878	54,187	22.60
South	46,219	82,687	34.40	127	224	34.53	46,092	82,463	34.40
West	40,293	60,443	25.14	104	153	23.65	40,189	60,290	25.15
Vascular Injury	2,600	4,194	1.74	47	75	11.54	2,553	4,120	1.72
Spinal Fracture	1,672	2,709	1.13	18	28	4.34	1,654	2,681	1.12
Pelvic Fracture	5,649	9,180	3.82	69	110	16.96	5,580	9,070	3.78
Lower Extremity Fracture	21,519	35,640	14.83	130	212	32.67	21,389	35,428	14.78
Head Injury	29,193	47,913	19.93	155	250	38.55	29,038	47,663	19.88
Open Reduction/ Fixation of Lower Extremity Fracture	21,967	35,899	14.93	90	142	21.92	21,877	35,757	14.92
Central Venous Line Placement	4,319	7,104	2.96	89	141	21.75	4,230	6,963	2.90
Laparotomy	1,225	1,991	0.83	18	28	4.27	1,207	1,963	0.82
Craniotomy	1,257	2,050	0.85	10	16	2.50	1,247	2,034	0.85
Spinal Procedure	937	1,490	0.62	13	20	3.13	924	1,470	0.61
Total	146,512	240,387	100.00	405	648	100.00	146,107	239,740	100.00

Table 2. Mean Age, Length of Stay, and Total Costs, Overall and by DVT Status

	All Traumatic Injuries		With DVT		No DVT	
Parameter	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Age	12.16	6.33	16.59	4.42	12.15	6.33
Length of Stay	4.24	8.28	22.55	21.64	4.19	8.16
Total Costs	$10,999	$21,312	$69,865	$74,067	$10,843	$20,777

Regression Estimates

Table 3. Adjusted Incremental Effect of Injury Severity on Probability of DVT

Explanatory Variables*	Odds Ratio	Std. Error	Lower 95% C.I.	Upper 95% C.I.	P-Value
Minor Injury (reference category)			---		
Moderate Injury	2.13	0.18	1.49	3.05	<0.0001
Severe Injury	2.49	0.24	1.56	3.96	0.0001
Critical Injury	3.53	0.29	2.01	6.22	<0.0001

Table 4. Adjusted Incremental Effect of Injury Severity and DVT on LOS

Explanatory Variables*	Coefficient	Std. Error	Lower 95% C.I.	Upper 95% C.I.	P-Value
DVT	12.80	1.96	8.95	16.65	<0.0001
Minor Injury (reference category)			---		
Moderate Injury	1.76	0.09	1.58	1.94	<0.0001
Severe Injury	3.75	0.17	3.41	4.10	<0.0001
Critical Injury	9.41	0.37	8.69	10.14	<0.0001
DVT X Minor Injury (reference category)			---		
DVT X Moderate Injury	-0.53	2.41	-5.26	4.19	0.8244
DVT X Severe Injury	11.09	4.69	1.90	20.29	0.0181
DVT X Critical Injury	7.11	2.87	1.48	12.75	0.0133

Table 5. Adjusted Incremental Effect of DVT and Injury Severity on Total Costs

Explanatory Variables*	Coefficient	Std. Error	Lower 95% C.I.	Upper 95% C.I.	P-Value
DVT	$44,741	$12,004	$21,205	$68,276	0.0002
Minor Injury (reference category)			---		
Moderate Injury	$5,851	$216	$5,429	$6,274	<0.0001
Severe Injury	$12,307	$508	$11,312	$13,303	<0.0001
Critical Injury	$34,111	$1,214	$31,731	$36,491	<0.0001
DVT X Minor Injury (reference category)			---		
DVT X Moderate Injury	-$11,085	$12,570	-$35,731	$13,562	0.3779
DVT X Severe Injury	$23,326	$15,879	-$7,807	$54,458	0.1419
DVT X Critical Injury	$22,371	$14,336	-$5,738	$50,480	0.1187

*Only parameters of interest presented here; parameter estimates for other measures, as described previously, available upon request.

Results

Incidence and Patient-Specific Characteristics (Tables 1 and 2)

- There were 240,387 pediatric trauma-related discharges in 2003
- Among all pediatric trauma admissions, 648 (0.27%) had evidence of DVT, consistent with previous estimates found in the literature[4]
- Among DVT-related hospitalizations:
  — Nearly three-quarters were for male patients (~72%)
  — More than 22% had minor injuries, 26.18% had moderate injuries, 20.66% had severe injuries, and 26.22% had critical injuries; 4.72% of DVT-related hospitalizations had an unknown or indeterminate injury score, and were not used in subsequent regression models
  — The majority of stays were in teaching hospitals, were in an urban-based facility, and the greatest proportion was in the South (34.55%)
  — Approximately one-third of these stays had evidence of lower extremity fracture (32.67%) or head injury (38.55%)
  — More than 20% of these stays had evidence of a reduction/fixation of a lower extremity fracture (21.92%) or central venous line placement (21.75%)
  — The mean age, LOS, and total costs were greater for those with DVT than those without, 16.59 vs. 12.15 years, 22.55 vs. 4.19 days, and $69,865 vs. $10,843, respectively

Regression Results (Tables 3, 4, and 5)

- Moderate, severe and critical injuries significantly increased the likelihood of DVT (Odds Ratio=2.13, 2.49, and 3.53, respectively), as compared to minor injuries

- DVT independently had a significant effect on LOS (12.8 additional days), and compared to minor injuries, moderate, severe and critical injuries each significantly increased LOS (1.76, 3.74 and 9.41 additional days, respectively). Further, relative to minor injuries, severe and critical injuries among those with DVT (i.e., interactive effects) were associated with a significant increase in LOS (11.09 and 7.11 days, respectively)

- DVT and increasing severity each independently increased total costs, but interactive effects were not statistically significant

Conclusions

In this study we quantified the effect of injury severity on the incidence and utilization-related outcomes of DVT among those with traumatic injury in a multi-payer US pediatric population. Increasing severity appears to increase the likelihood of developing a DVT, and DVT, increasing injury severity, and interactions between the two generally increase both LOS and total costs among pediatric trauma patients. New interventions that mitigate the development of DVT may reduce the economic burden of traumatic injury among pediatric hospitalizations. Clinicians and other decision makers should be aware of the relationship between injury severity and DVT development and subsequent resource utilization-associated outcomes.

Limitations

Conditions and events of interest were categorized based upon diagnosis codes, which, if recorded inaccurately, may cause misidentification of DVT or nature of traumatic injury, or misclassification of injury severity.

References

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Presented at: the ISPOR 13th Annual International Meeting
May 3-7, 2008
Toronto, Ontario, Canada

This project was funded in part by the Agency for Healthcare Research and Quality (R03 HS017344-01)